A proposed Approach to Monitoring and Assessing Drought in the Caribbean

By

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ABSTACT

Climatological events over the past two decades have prompted the Caribbean Institute for Meteorology and Hydrology (CIMH) to pay closer attention to drought in the region. Drought, on some occasions related to the ENSO phenomenon, has resulted in great losses, particularly in the agriculture industry and disruption of domestic water supplies. It is anticipated, that due to climate change, these events will become more frequent in the future. One way to deal with the impacts of climate variability and change and the uncertainty surrounding these is to establish monitoring and early warning systems for extreme events like drought in vulnerable communities to monitor trends. Such important information enables governments and communities to plan for and respond effectively to the challenges of climate-related events. To this end, CIMH has teamed with the Brace Centre, McGill University under the Caribbean Water Initiative (CARIWIN) project to initiate the Caribbean Drought and Precipitation Monitoring Network (CDPMN). A number of precipitation indices and other indicators are being investigated to monitor drought the Caribbean. These indices also provide information on periods of above normal rainfall, allowing the monitoring of both extremes – drought and flood. Combined with the Precipitation Outlook currently produced by CIMH, drought and precipitation projections can also be made for up to at least three months. The CDPMN will also afford an opportunity for a participatory process, between CIMH, national and local governments and pilot communities, to propose new Community Water Strategies which consider the extremes of drought and flood for water resource management in Jamaica, Grenada and Guyana.

Keywords: Drought, monitor, indices, network climate change, early warning systems, drought planning

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1. Introduction

The Caribbean Meteorological Organisation is comprised mainly of island nations located in the Caribbean Sea and Guyana and Belize in South and Central America, respectively. These countries lie between latitudes 5º and 25º N and longitudes 55º and 90º W, representing mainly the English-speaking Caribbean. The countries are geologically, environmentally, politically, socio-culturally and economically diverse. The geographical scope leads to variations in climatological and ecological conditions across the countries.

Rainfall in the Caribbean islands and Belize is characterized by a wet and a dry season. The wet season normally begins in May to June and finishes in November to December. At least 70 to over 80 % of the rainfall occurs, on average, during the wet season in these locations (Enfield and Alfaro 1999). In the case of Guyana, in particular the northern portion, the influence of the Inter Tropical Convergence Zone is responsible for the two wet and dry seasons per year. The seasons express much variability in commencement (Trotman 1994), duration and rainfall quantities. It is not unusual to experience significant dry spells during the wet season or very wet spells in the dry season (Trotman 1994). This variability can be attributed to a number of features including the El Niño Southern Oscillation (ENSO) and sea surface temperature anomalies in the tropical north Atlantic (Taylor et al. 2002, Stephenson et al. 2008, Giannini et al. 2001, Enfield and Alfaro 1999, Laing 2004) and the North Atlantic Oscillation (Charlery et al. 2006). Caribbean rainfall is also characterized by cycles of the order of about 50 years (Figure 1, Burton 1995), which suggest phases of high and low rainfall, with significant inter-decadal variability. Also, during the low phases, water shortages will be more regular occurrences.

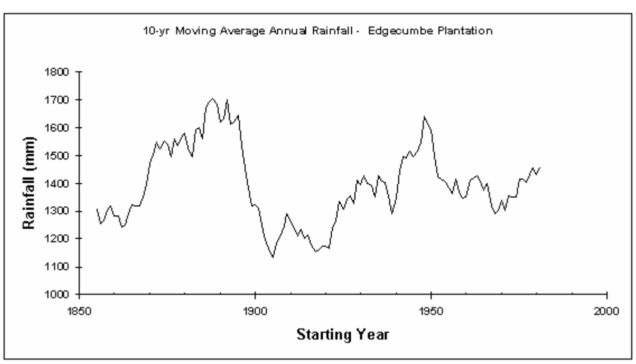


Figure 1 Moving 10 year averages of rainfall at Edgecumbe, Barbados (Burton 1995)

With limited peer reviewed information for the Caribbean, the IPCC in its Fourth Assessment Report (Mimura et al. 2007) projects that there is a 90% chance that temperatures will rise across the Caribbean. Average of 21 models suggest the increase in the annual temperature could be in the range of 2 to 2.5^{o}C (Christensen et al. 2007). There is however, greater uncertainty in the rainfall projections in the region, particularly in the Lesser Antilles. None-the-less, it is projected that rainfall is likely (66%) to decrease in the Greater Antilles during the months from June to August. Most models predict a decrease in annual precipitation in the region of 5 to 15 % with the greatest change during the months of June to August (Christensen et al. 2007). It is therefore anticipated that droughts will become more frequent in the future.

This paper discusses an approach under way at the Caribbean Institute for Meteorology and Hydrology (CIMH) to monitor extreme precipitation (particularly drought) in the Caribbean, which will aid in preparation for these hazards and the mitigation of potential losses and disruptions in the varying sectors, including agriculture, in the region.

2. Overview of the impacts of droughts in the Caribbean

The Caribbean has many examples of the impacts of drought, which normally result in great losses, particularly in the agriculture sector. During drought, low rainfall have resulted in decreased crop yields, domestic water shortages, drained reservoirs, reduced river and stream flows, and reduced water for swamp and mangrove ecosystems. Increased competition for water and enhanced development activities such as housing and road schemes due to increased population pressures have increased the vulnerability of communities and nations to drought. Drought conditions also support other potential hazards, such as forest and bush fires. Being able to anticipate drought through constant monitoring via indices and other climatic indicators as well as biological observations, is a key component in reducing vulnerability. It allows for mobilization of resources and preparation that increases the coping capacity of communities and nations.

In 1998, Guyana experienced water rationing, cessation of logging and river transport in some places and the loss of livestock due to drought caused by El Niño (National Drought Mitigation Center 1998). Rice farmers were forced to leave 35 % of their rice fields uncultivated and affected more than 1500 Amerindian families in Southern Guyana, reliant on agriculture (USAID 1998). Jamaica experienced below normal rainfall from December 1996 into 1998. The greatest damage occurred in the agricultural sector[1]. Losses in the sugar sector prompted the Jamaican government to offer the sector a US$100 million assistance package late in 1997[2]. Later, during the 1999-2000 drought, where rainfall was less than 25 % of the average in some places, Jamaican authorities reported crop losses of approximately US$6 million between October 1999 and March 2000 (Jamaican Information Service 2007). One of the islands making up Grenada, Carriacou, experiences less rainfall than the main island. Carriacou also accounts for 30% of the nation's livestock production, and experienced losses of 20 and 40% due to drought in 1984 and 1992 respectively (UNFCCC 2000). Forest fires in Trinidad normally occur during the dry season (January to May). The extent of damage is normally related to the intensity of the dry season. In 1987 over 10,000 acres of natural forests on the island were burned and losses of agricultural crops and property are estimated at an average of US $500,000 per annum (http://www.fao.org/DOCREP/006/AD653E/ad653e96.htm).

3. The need for Drought Monitoring in the Caribbean

Droughts range in intensity, duration (weeks to years) and spatial extent (which is normally greater than for other climate hazards). It is a slow, creeping disaster in the making. You may only recognise it is happening when it is already upon you – then it might be too late. Drought impacts are normally cumulative and the effects are magnified when occurring from one season to the next[3]. There is therefore the need to closely monitor precipitation for such occurrences.

If we interpret drought as a 'water shortage', distribution of water during dry seasons in our region is a nightmare for water resources managers, agriculturists and ecosystem managers. The region's booming tourist industry is no less

[1] http://www.odpem.org.jm/pdf/DROUGHT%20ALERT.pdf
[2] http://www.nationsencyclopedia.com/economies/Americas/Jamaica-AGRICULTURE.html
[3] Drought, living with risk: An integrated approach to reducing societal vulnerability to drought. ISDR Ad Hoc Discussion Group on Drought. http://www.unisdr.org/eng/task%20force/tf-adhoc/droughts/WGD-doc1.pdf

vulnerable, as the dry season (which coincides with the boreal winter season) realizes the heaviest influx of visitors to the region and a greater strain on the water supply. This does not at all suggest that there are no concerns during the wet season. The nature of Caribbean climate is such that dry spells during the wet season are not unusual and can have great impacts on agro-ecosystems and biodiversity.

It is anticipated, that due to climate change, these extremes in rainfall will increase in frequency. The impacts of these are also expected to increase due to societal behaviour. Having a drought and precipitation monitoring and early warning systems in place would not only be an asset now, but may become increasingly important in the future. Having such a culture in place now is therefore important in the management of such situations.

It is for these reasons that the Caribbean Institute for Meteorology and Hydrology (CIMH) has proposed and is pursuing the development of the Caribbean Drought and Precipitation Monitoring Network (CDPMN).

4. Basic Approach of CDPMN

The concept was born out of the need to mitigate and respond to the creeping phenomenon, drought, as well as to cope with the other extreme; flooding. Unless precipitation is closely monitored, countries often do not realize that that they are in or approaching drought status until it is upon them. However, many of the indices and indicators used to recognize drought occurrence are also used to determine different severities of above normal precipitation, and therefore above normal precipitation can also be monitored.

Drought and the general precipitation status of countries will be monitored using a number of indices (e.g. Standardized Precipitation Index, SPI; The Palmer Drought Severity Index, PDSI; and the Crop Moisture Index, CMI), which, by their values express different severities of drought and above average water; and indicators (e.g. water levels, state of vegetation and ecosystems). However, the final drought and precipitation status of the region/country will be determined, by consensus, by a network of persons from different sectors, institutions and communities embracing the diversity in definitions and impacts of drought.

As an addition to the drought status product(s), short term and seasonal precipitation forecasts will be used to provide a projection of future drought in the short and medium terms. An example of probability precipitation forecast for the Caribbean can be seen in Figure 2

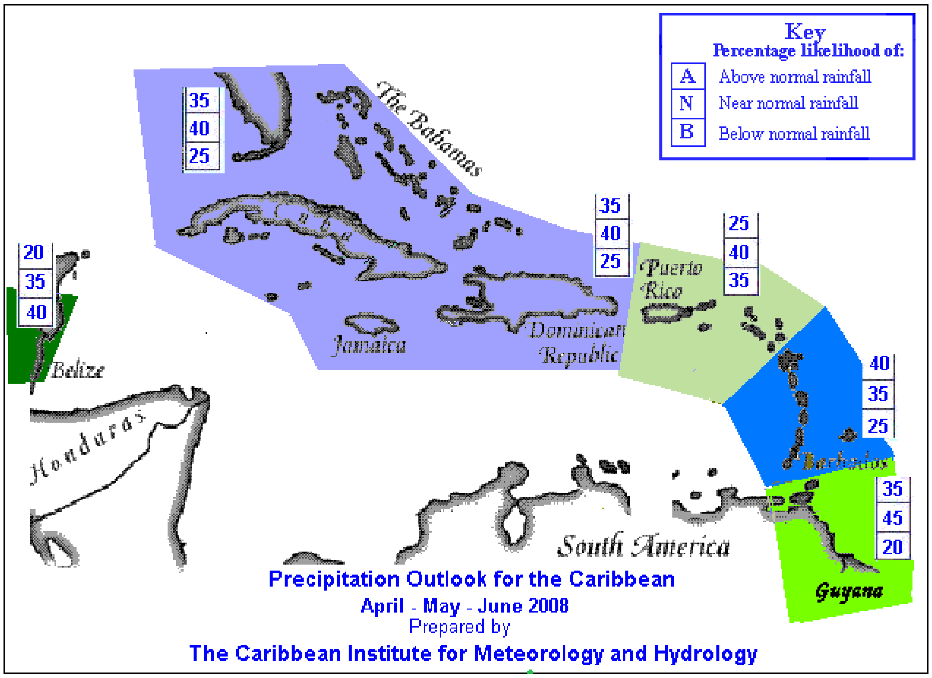


Figure 2 Precipitation Outlook for the Caribbean

CIMH has teamed with the race Centre McGill University, Montreal, Canada to begin work on the CDPMN, using the pilot countries (Guyana, Grenada and Jamaica) under the Caribbean Water Initiative (CARIWIN http://www.mcgill.ca/cariwin/) project to initiate networks within these countries. CARIWIN is expected to enhance integrated water resources management and drought monitoring and will aid in facilitating this. It is expected that this activity will be expanded to other CARICOM countries in the future through other projects.

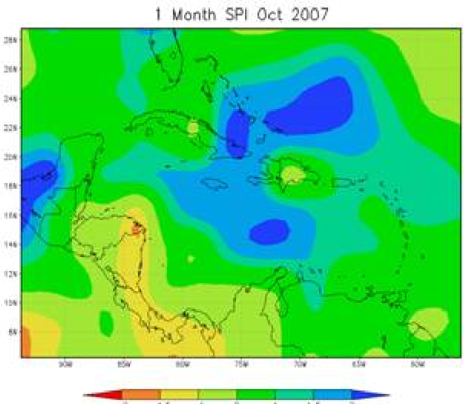
5. Drought and Precipitation Indices

A number of drought/precipitation indices are currently under investigation at CIMH, with the view to them being used together to monitor drought and periods with above normal precipitation.

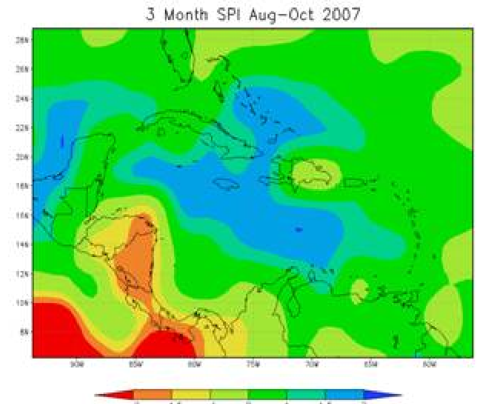
The Standardized Precipitation Index (McKee et al. 1993) is one such index under investigation. It utilizes precipitation information only, where historical data is placed in severity classes such that an index value of 1 represents one standard deviation from the mean. Using data from the IRI (International Research Institute for Climate and Society) the precipitation status over particular time periods can be monitored. Examples of these are shown in Figures 3a, 3b and 3c for 1-month, 3-month and 6-month periods.

CIMH is also investigating the application of the PDSI (Palmer 1965) and its derivative, the CMI. These shorter term indices (estimated on a 1-month and 1 week basis respectively) have often been used to identify and classify drought in the agriculture sector. Unlike the SPI, both these indices utilize precipitation, evaporation and soil water capacity data. Figures 4a and 4b show how the PDSI can be used in assessing agricultural drought risk during different times of the year in Barbados. The maps show at worst, on average, mild drought in April and incipient drought in October in some parts of the country. These average maps differs from those in 1998 (an El Niño year), when conditions were drier than normal (Figure 5a and b), also showing the large variability in conditions intra-annually. Figure 6 shows a strong relationship between the CMI, estimated available soil water and actual measured soil moisture content at CIMH, suggesting that the CMI could well be an asset to the monitoring of agricultural drought in Caribbean conditions. Further investigations will be made.

a)



b)



c)

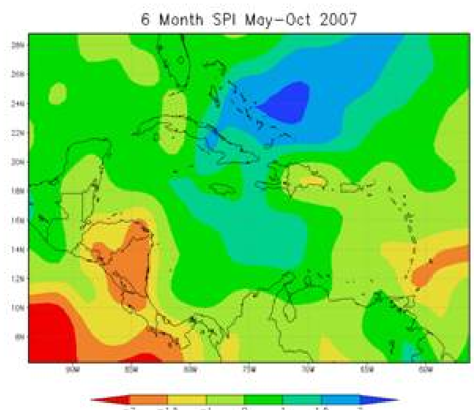
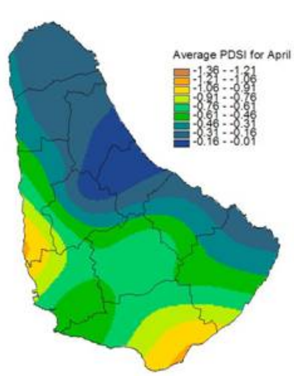


Figure 3. a) 1-, b) 3- and c) 6 - month SPI for the Caribbean for October 2007

a)



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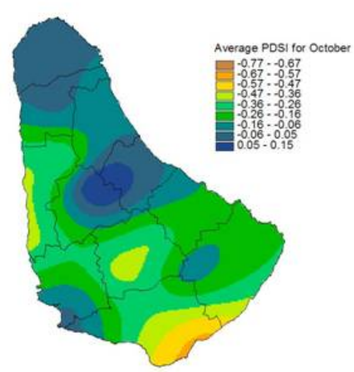
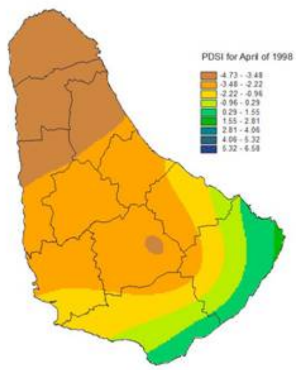


Figure 4 Mean PDSI values for April and October for Barbados

a)



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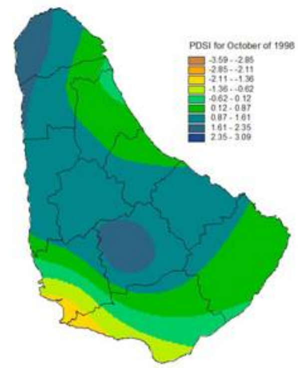

Figure 5. PDSI values for April and October 1998 (an El Niño year)

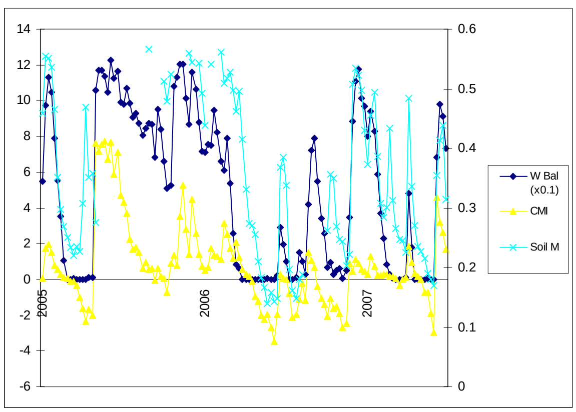

Figure 6 Weekly CMI values compared with weekly measured volumetric soil moisture content (Soil M) and calculated available soil water (W Bal) at CIMH, Husbands from 2005 to 2007.

6. Mainstreaming drought information into decision making

Mainstreaming drought information is about integrating climate indices and indicators into routine decision making processes. For example, taking into account the occurrences of drought can be considered as yet another layer of managing risk when deciding on water management, cropping system changes, or new infrastructure to put in place, or new policies to implement. Mainstreaming is about incorporating existing information into risk management and decision making as a prudent way of moving forward, and to increase the resilience of a community to extreme events.

Managing the impacts posed by climate is one more layer to take into account when managing risks. Successful adaptation measures to extremes enable governments and communities to plan for and respond effectively to the challenges of climate-related events. This is all part of an integrated water resources management (IWRM) plan.

Given the complexity, uncertainty and increasing vulnerability of both natural and human systems, water managers around the world agree that the only way forward is through an inclusive and integrated approach to water resources management (UNESCO 2006). The drought information made available by the CDPMN will be accessible to stakeholders and will constitute a valuable IWRM tool in the decision-making process. The CDPMN will be web-based and therefore improve timeliness of, and broaden access to, drought and flood information for decision-making.

7. Outcomes and benefits expected from CDPMN

The network will assist to better manage water resources, and aid with planning and preparing for adaptation to drought and heavy precipitation / flooding events, which are a real threat.

The network has four main outcomes:

1. Monitoring of the current status of precipitation via the hydrometric stations and sensor data, monitor hydrological indicators (i.e. water levels), climate indicators (i.e. precipitation), and other indicators (i.e. soil moisture) to determine trends of these
2. Undertake projections of drought through the coupling with regional seasonal precipitation probability forecasts for up to months

3. Implement early warning systems via the CIMH website by updating relevant information and posting warnings. Networking with key agencies, governments, media, etc. in partner countries to disseminate the information
4. Build adaptation and response strategies to drought events through a network of researchers working with stakeholders including all levels of government gaining knowledge on the potential future occurrences of extremes, and examining the impacts that these will have on the community, while providing input on how to cope with and respond to these events.

Conclusion

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